

Limitation of the Use of Lay-in Insulation in Nonresidential Buildings



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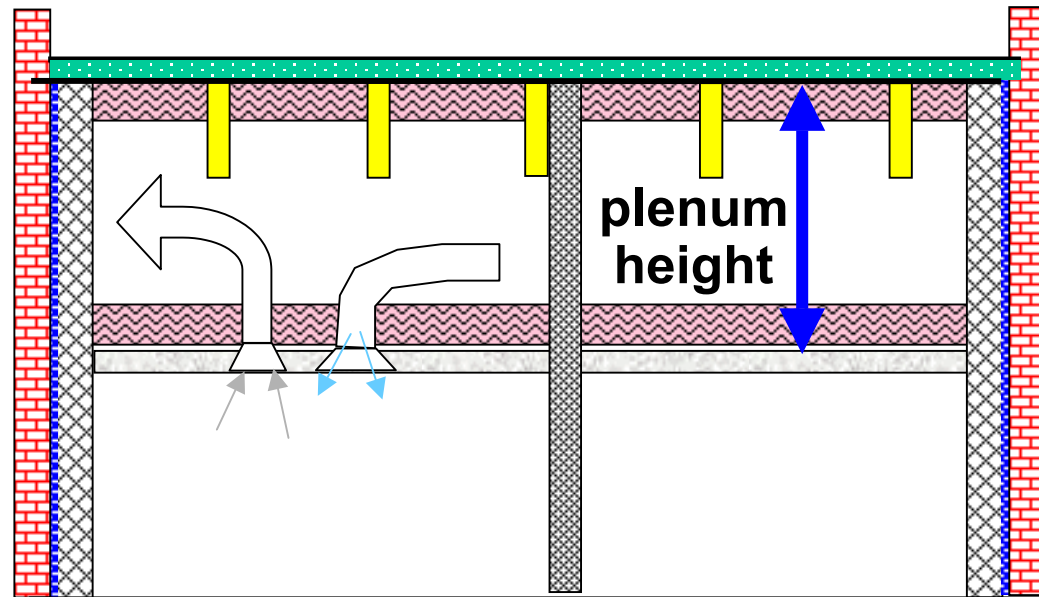
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Introduction

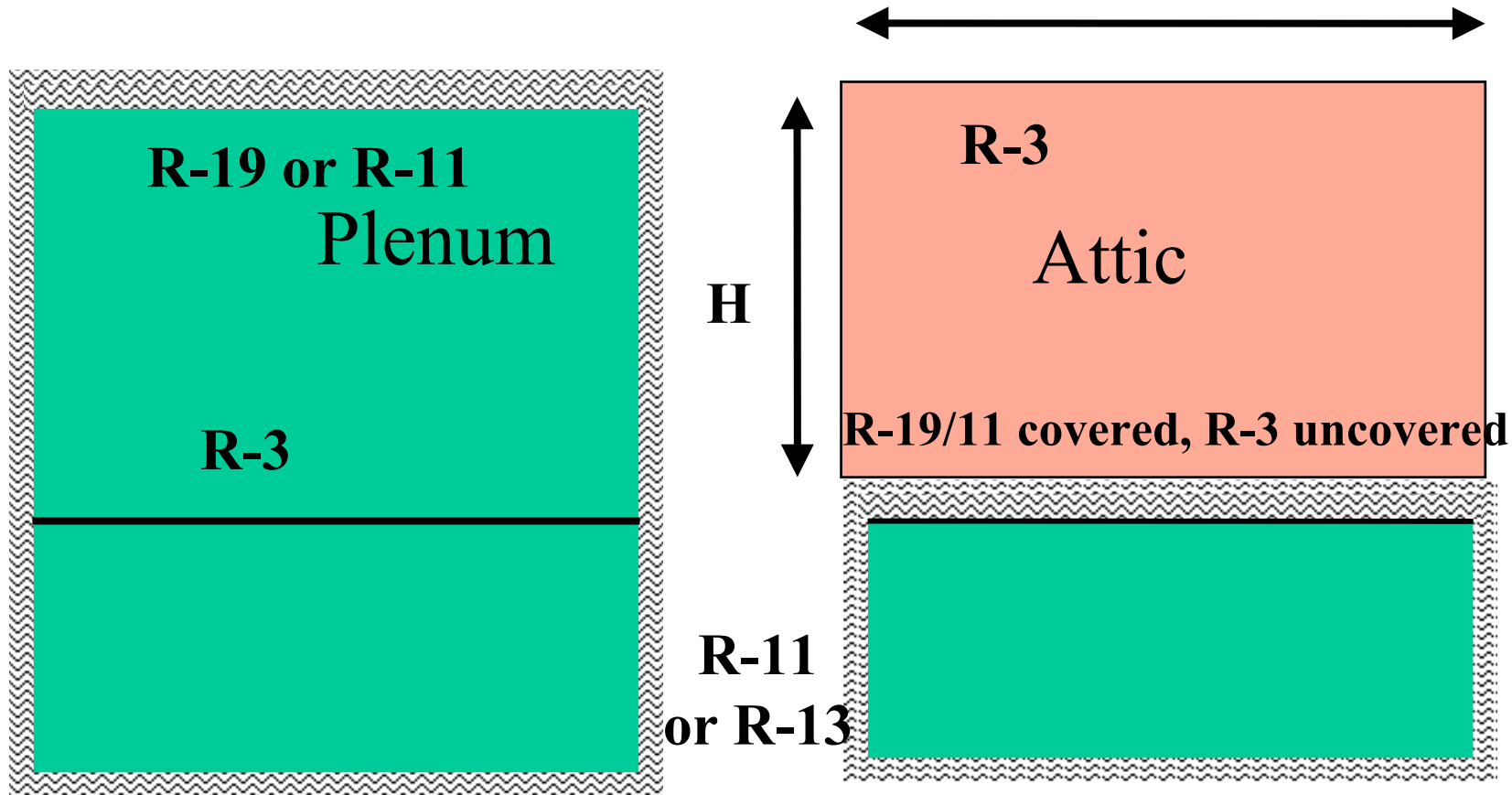
- Laying insulation on top of an acoustic tile ceiling is NOT equivalent to insulating the roof deck of commercial buildings
- Insulating roof decks and side walls of plenum below the roof deck instead of laying insulation directly on t-bar ceiling is cost-effective when plenum heights are < 12 ft
- This proposal restricts the use of insulation on T-bar ceilings
 - except when plenum height > 12 feet

Insulation Locations

- Lay-in insulation above acoustic tiles on t-bar ceiling
- Insulation above a drywall ceiling
- Insulation below the roof deck
- Rigid insulation above the roof deck



Insulation Trade Offs



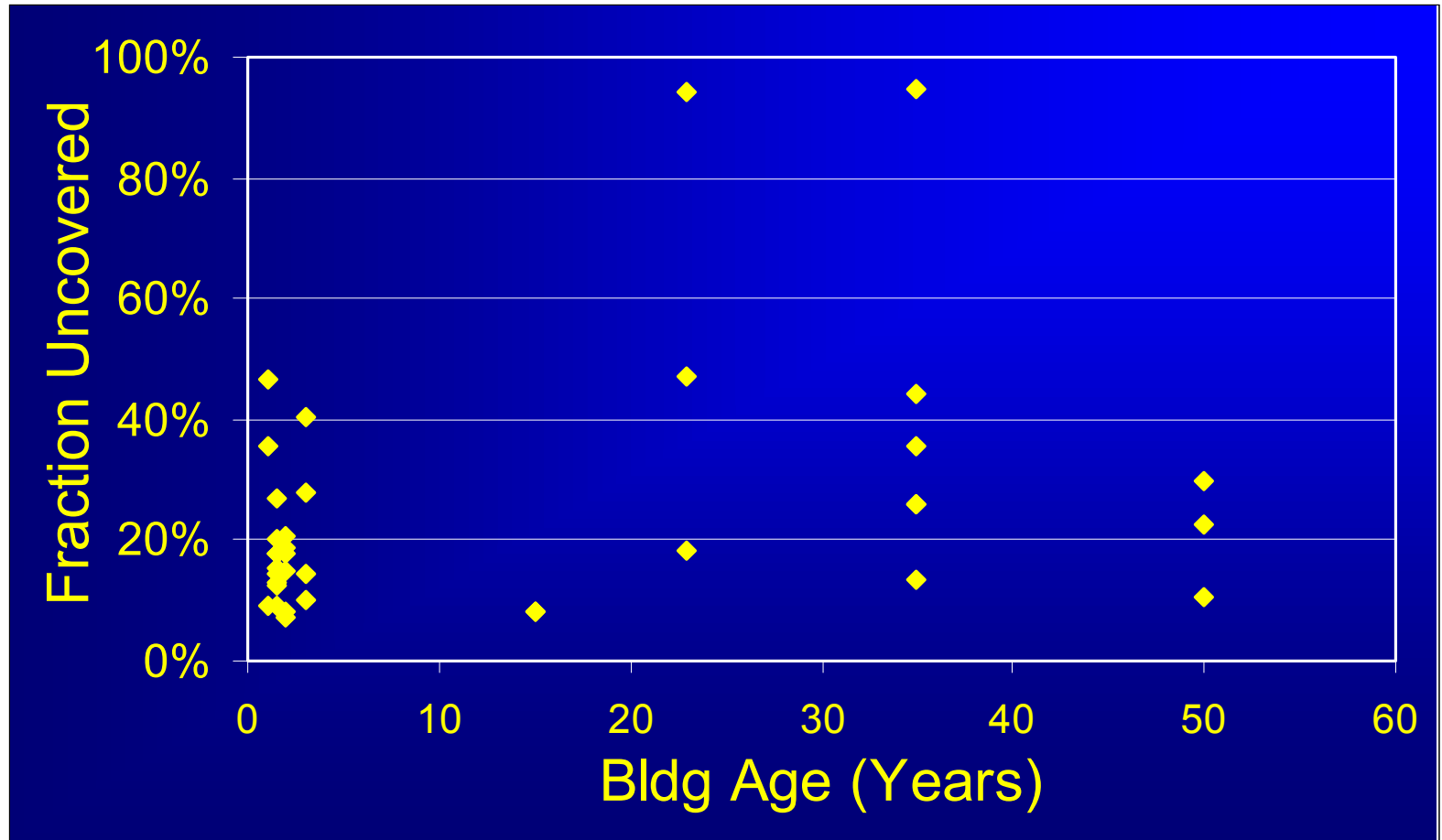
NB I/PIER Lay-in Insulation Surveys

- Research on lay-in insulation effectiveness
- Hypothesis: significant fraction of lay-in insulation missing
 - Corollary hypothesis: lay-in insulation coverage diminishes over time
- Visited 13 buildings (46 observations)
- Voids in insulation from a high of 95% to a low of 7%.
- All buildings have uninsulated troffers

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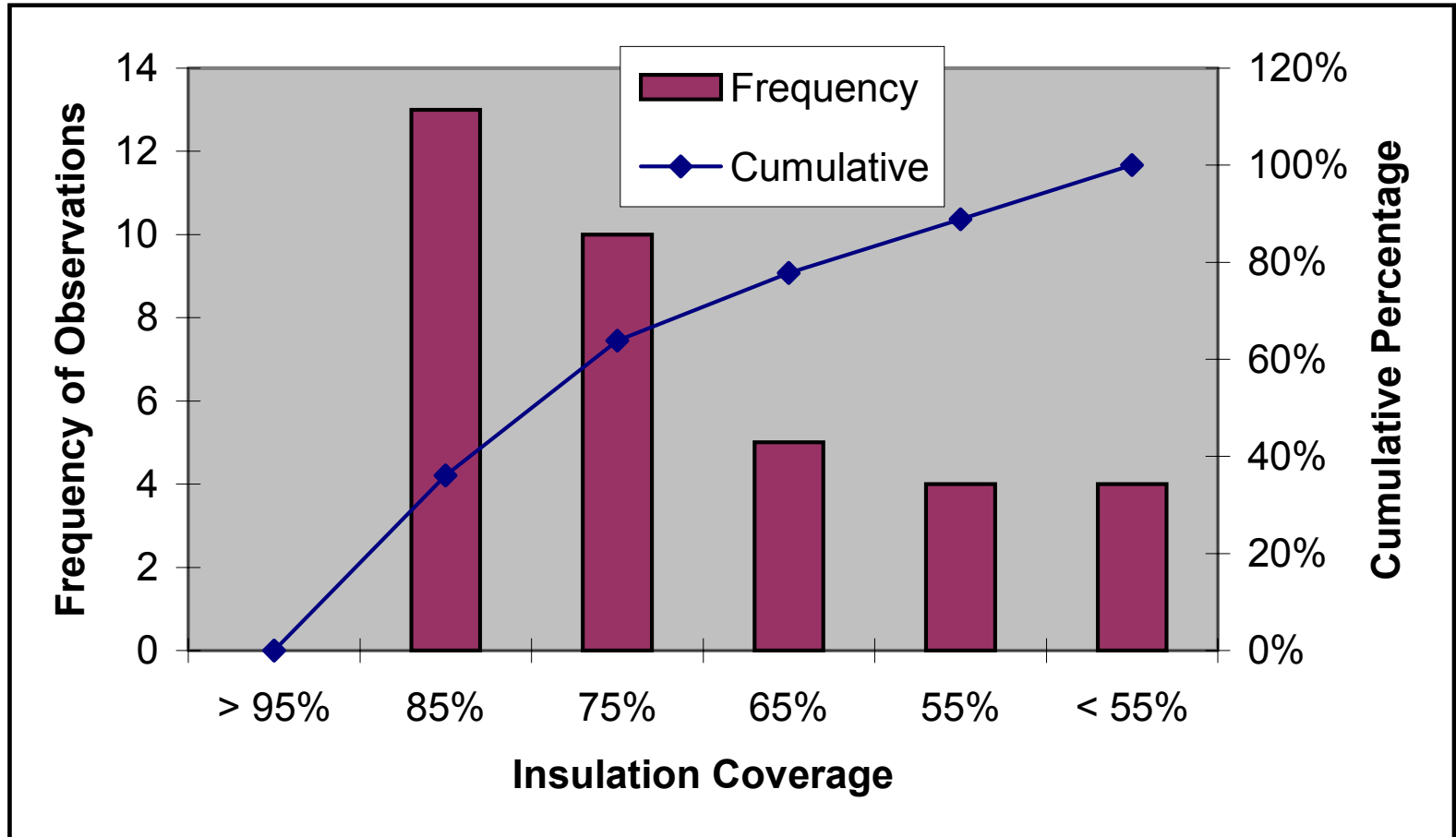


Lay-in Ceiling Site Measurements



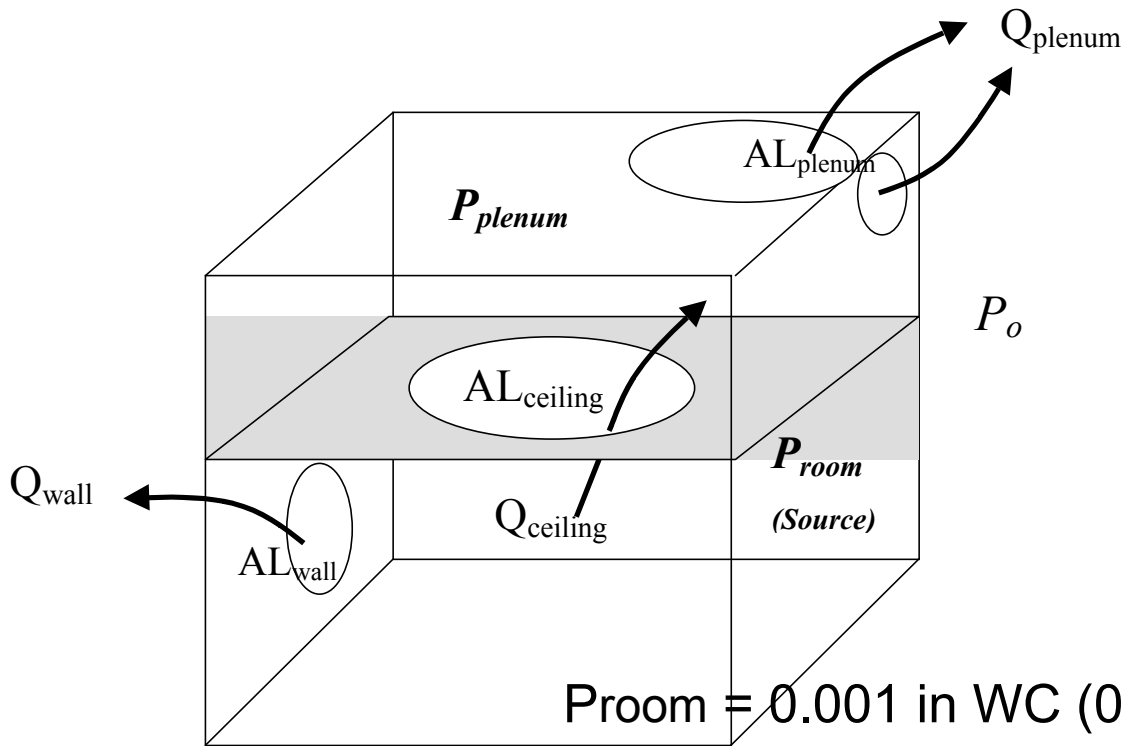
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Lay-in Insulation Frequency Histogram



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Pressure Model-Ceiling Infiltration



$P_{room} = 0.001$ in WC (0.249 Pa)

Based on 0.39 ACH for drywall ceiling

- FSEC T-bar ceiling leakage areas
- ASHRAE leakage areas for all other components
- Infiltration parallel heat path
- Increased ceiling effective U-factor

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Building Description

- Single story office space with area 2,000 sf
- Mass wall with troffers (LPD- 70% to conditioned space, 30% to plenum)
- Mass wall with pendant lighting (LPD 100% to conditioned space)
- Frame wall with pendant lighting (LPD 100% to conditioned space)
- T-bar ceiling infiltration values based upon FSEC research
- Other leakage areas from ASHRAE

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Cost of Insulation \$/SF

Installed costs including mark-up and overhead and profit.

- Above roof deck (rigid)- \$1.70/sf
- Below roof deck- \$0.97/sf
- Lay-in insulation- \$0.68/sf
- Masonry wall insulation- \$0.77/sf
- Frame wall insulation- \$0.56/sf

Cost of Duct Sealing/Insulation and Ceiling Construction \$/SF

- Ducts: sealing & increase insulation from R4.2 to R-8 - \$0.30/sf
- T-bar Ceiling - \$1.85/sf
- Drywall Ceiling - \$3.27/sf
- Insulation under the roof deck (\$0.97/sf) and no plenum wall insulation and loose ducts is equal or cheaper than lay-in insulation with tight ducts (\$0.68/sf + \$0.30/sf)

Cost Effectiveness Evaluation

- Only below deck insulation was considered
- More expensive above deck insulation selected for reasons in addition to reducing heat flows
 - No fibers in return plenum
 - Flat substrate for roofing over metal decks
 - Aesthetics for spaces without ceilings
- Single insulation position requirement desired for entire state.
- Flexibility of allowing lay-in insulation for small conditioned offices or other spaces in unconditioned buildings

Duct Sealing Benefit Cost Ratio - Mass Wall with Troffers

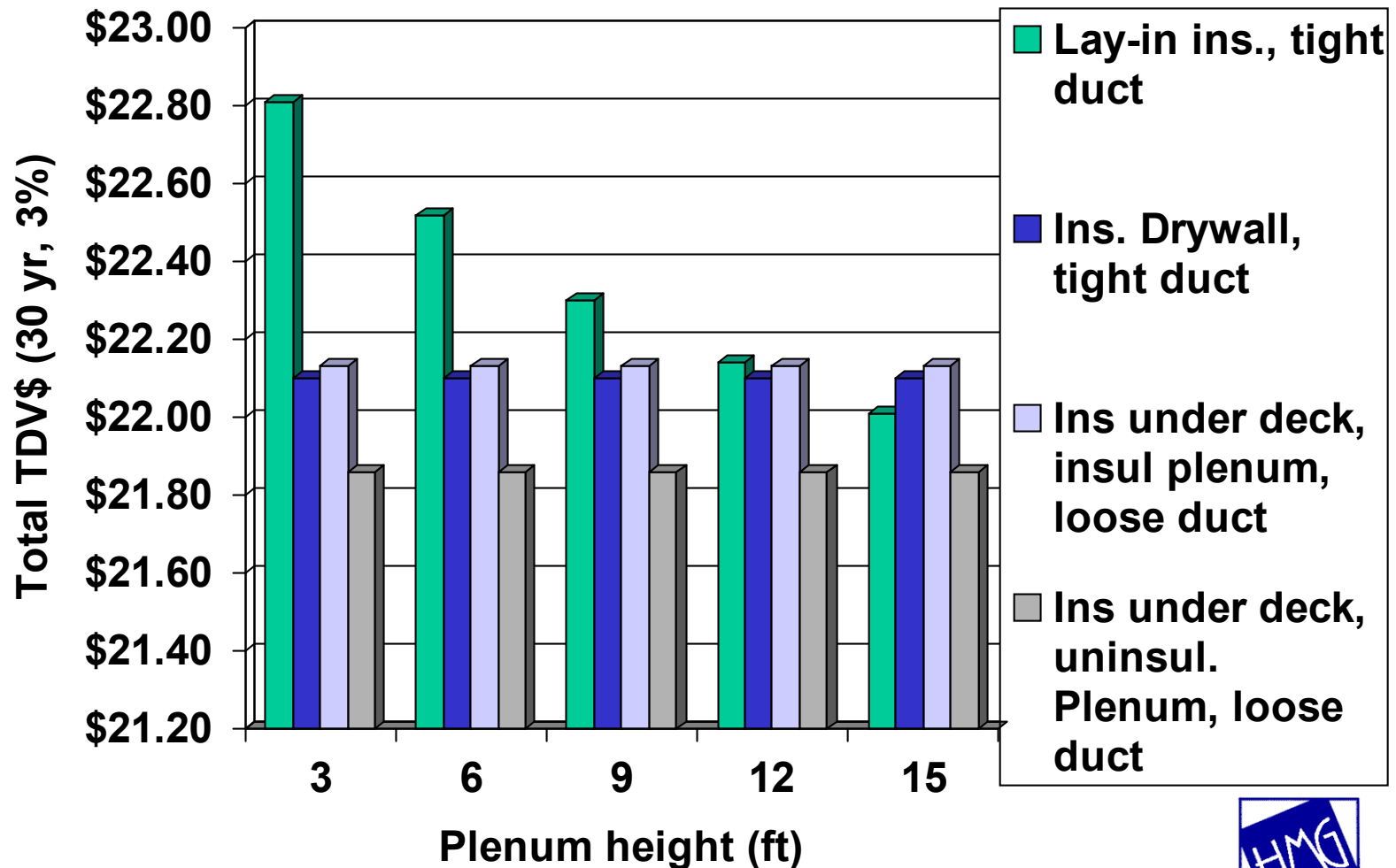
Climate Zone 3

Plenum Hts	Under deck-plenum insulated	Under deck-plenum uninsulated	Drywall ceiling	Lay-in-ceiling
3	0.66	0.89	3.61	2.79
6	0.71	1.09	3.39	2.84
9	0.75	1.23	3.24	2.88
12	0.79	1.35	3.11	2.90
15	0.83	1.44	3.00	2.92

Climate Zone 12

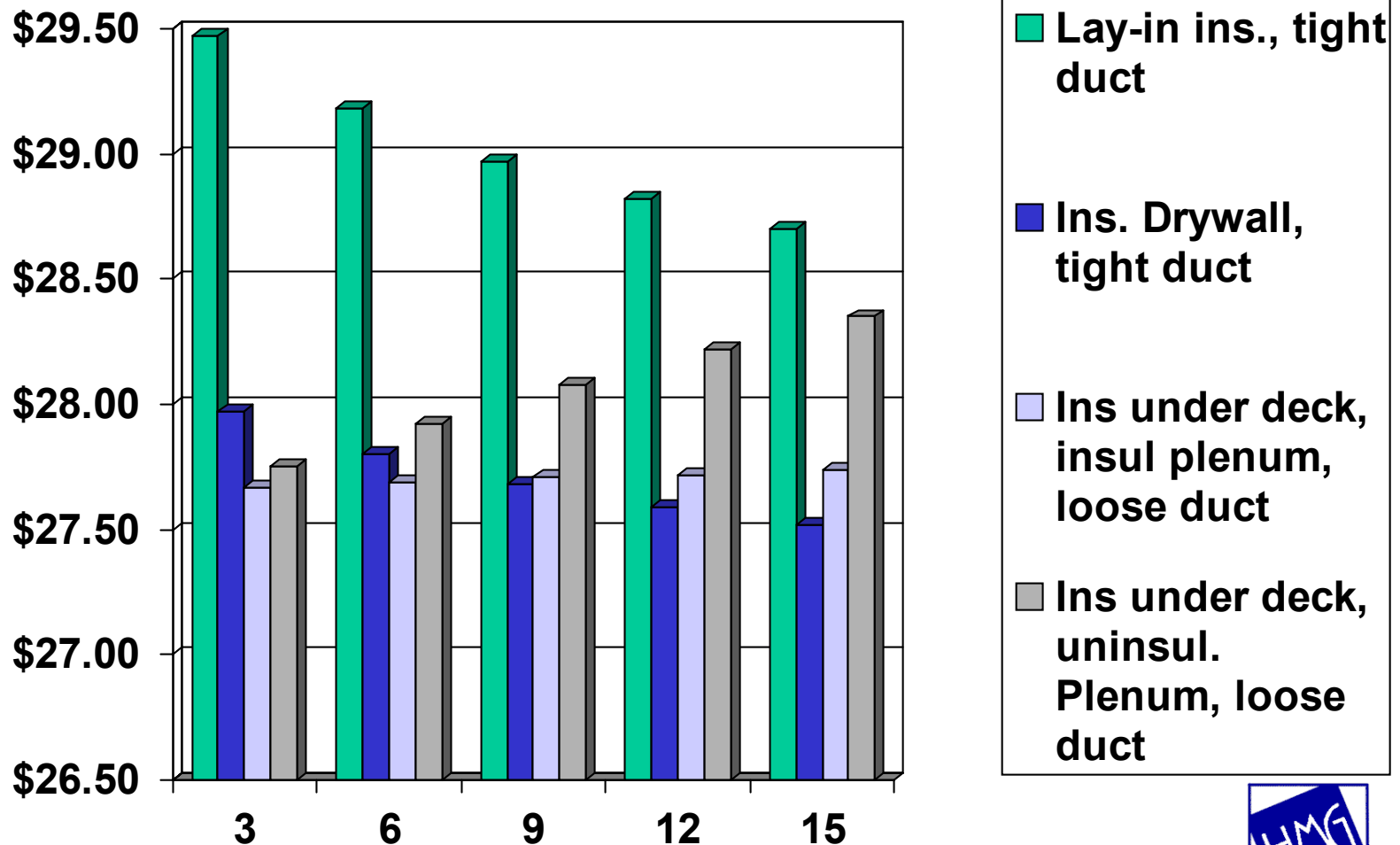
Plenum Hts	Under deck-plenum insulated	Under deck-plenum uninsulated	Drywall ceiling	Lay-in ceiling
3	0.87	1.31	6.72	4.81
6	0.95	1.85	6.65	5.06
9	1.03	2.31	6.62	5.28
12	1.08	2.71	6.60	5.49
15	1.15	3.09	6.60	5.70

Climate Zone 3 Masonry Walls Insulation Comparison TDV \$/SF



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Climate Zone 12 Masonry Walls Insulation Comparison TD V \$/SF



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Roof Deck Insulation B/C Ratio - Mass Wall with Troffers

Insulated Roofs with loose ducts or Drywall with tight ducts compared to Lay-in Insulated Ceilings with Tight Ducts

Climate Zone 3

Plenum Hts	Under deck-plenum insulated	Under deck-plenum-uninsulated	Drywall ceiling
3	3.31	Infinite *	0.49
6	1.03	Infinite *	0.38
9	0.41	Infinite *	0.29
12	0.16	Infinite *	0.23
15	0.03	Infinite *	0.18

Climate Zone 12

Plenum Hts	Under deck-plenum insulated	Under deck-plenum-uninsulated	Drywall ceiling
3	7.99	Infinite *	1.04
6	3.26	Infinite *	0.95
9	1.83	Infinite *	0.89
12	1.19	Infinite *	0.85
15	0.83	Infinite *	0.81

Duct Sealing Benefit Cost Ratio - Frame Wall with Pendant Lighting

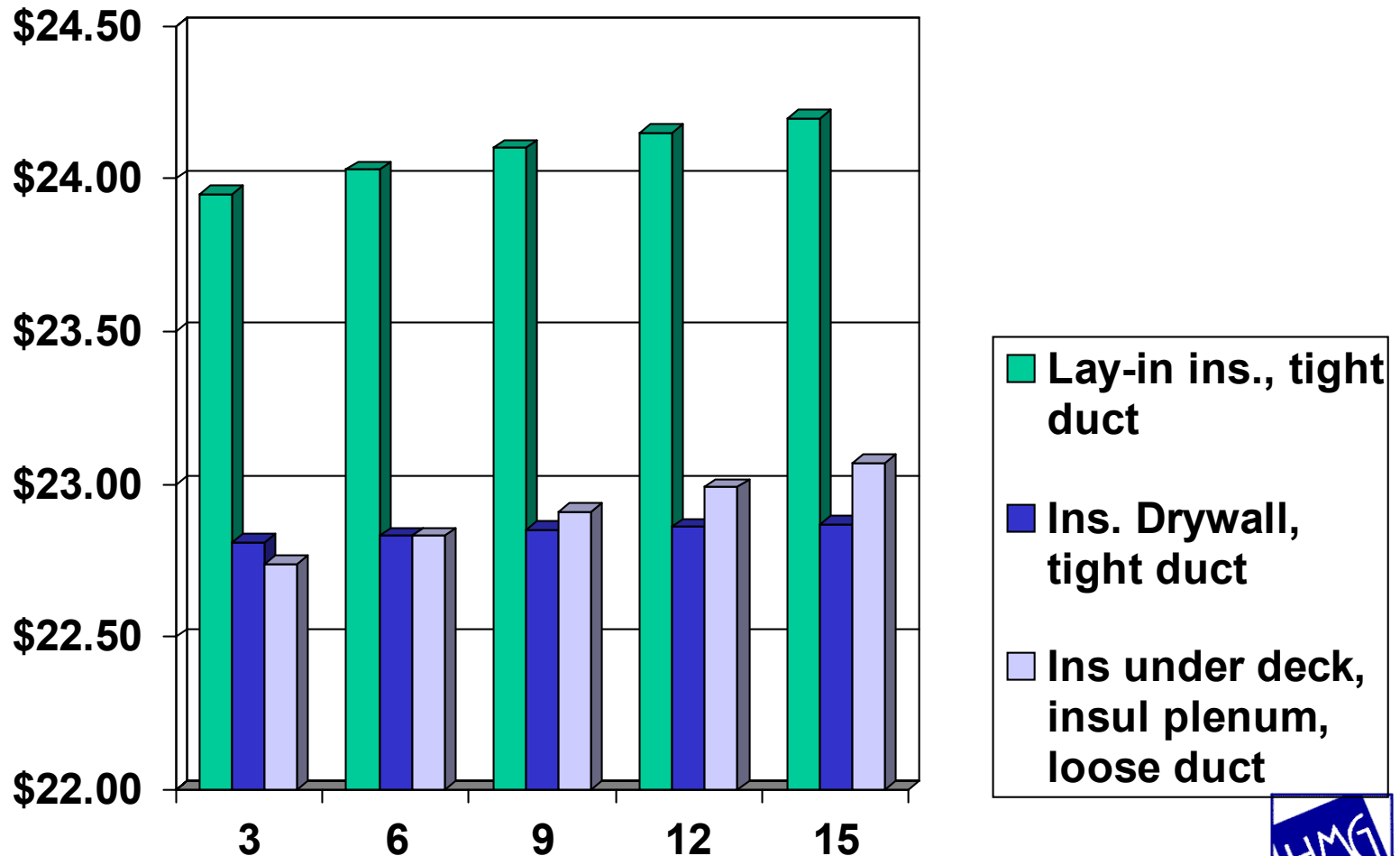
Climate Zone 3

Plenum Hts	Under deck-plenum insulated	Drywall ceiling	Lay-in ceiling
3	0.76	4.33	3.13
6	0.84	4.59	3.46
9	0.93	4.83	3.76
12	1.02	5.03	4.04
15	1.10	5.22	4.30

Climate Zone 12

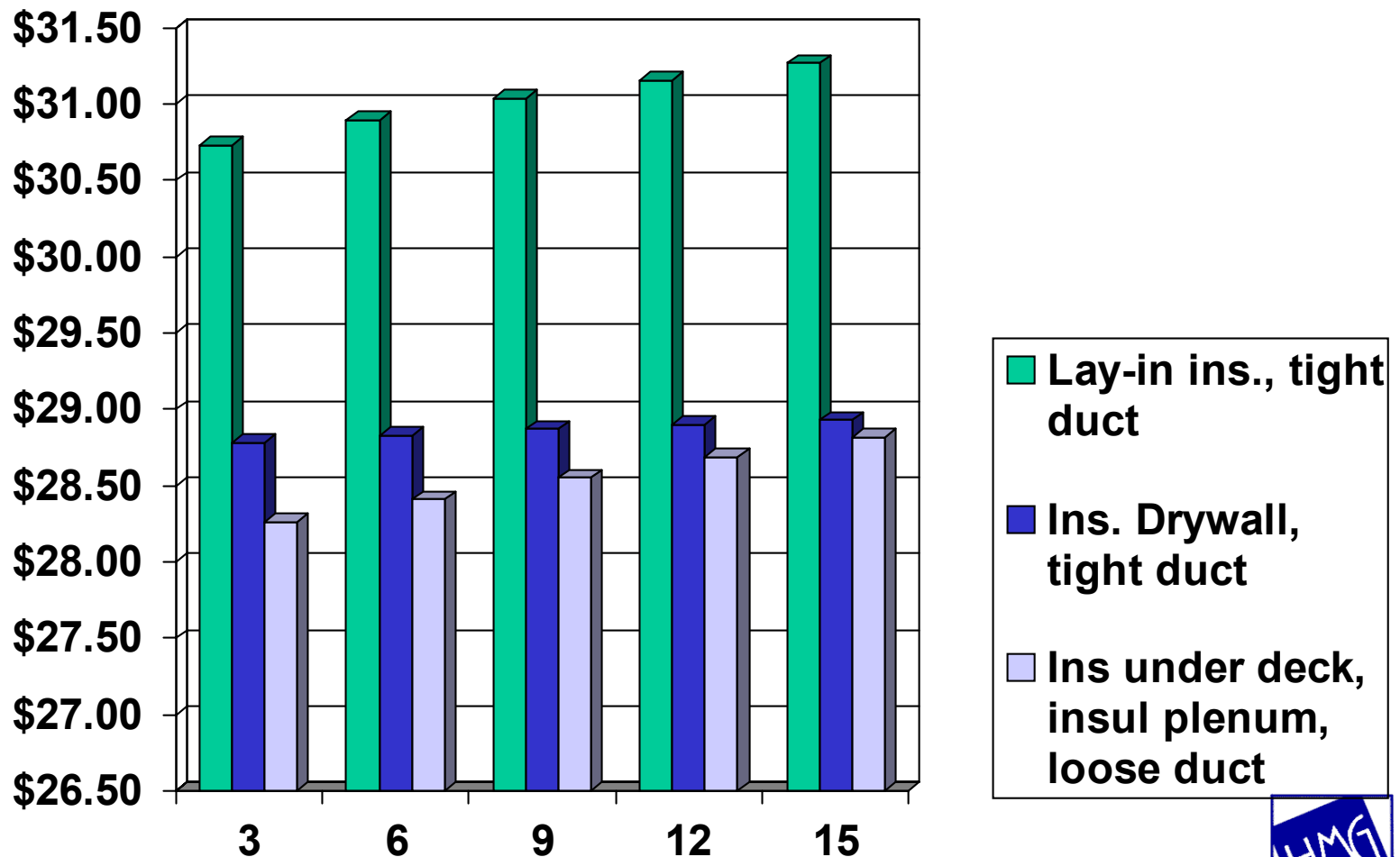
Plenum Hts	Under deck-plenum insulated	Drywall ceiling	Lay-in ceiling
3	0.93	7.61	5.24
6	1.04	8.26	5.92
9	1.15	8.86	6.58
12	1.27	9.39	7.20
15	1.40	9.86	7.76

Climate Zone 3 Frame Walls Insulation Position Comparison TD V \$/SF



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Climate Zone 12 Frame Walls Insulation Comparison TDV \$/SF



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Roof Deck Insulation Benefit Cost Ratio

– Frame Wall with Pendant Light

Leaky Ducts, Insulated Roofs vs Tight Ducts, Lay-in Insulated Ceiling

Climate Zone 3

Plenum Hts	Under deck-plenum insulated	Drywall ceiling-V
3	8.15	0.79
6	3.96	0.83
9	2.58	0.86
12	1.89	0.89
15	1.47	0.92

Climate Zone 12

Plenum Hts	Under deck-plenum-insulated	Drywall ceiling-V
3	15.41	1.35
6	7.62	1.43
9	5.04	1.50
12	3.74	1.56
15	2.95	1.61

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When is roof insulation cost effective?

- Mild climates (CTZ 3, 6):
 - Mass buildings when the plenum heights < 9 feet tall
 - Frame Buildings ALL plenum heights
- Warmer climates (CTZ 10, 12, 14):
 - ALL wall types up to 12 foot plenum heights

Should insulated dryw all ceilings be allow ed?

- Insulated drywall ceilings cost-effective only for frame construction in extreme climate zones.
- Drywall costs significantly more than standard grade T-bar ceilings.
- TDV energy costs of insulated drywall ceilings similar to insulated roof deck.
- Higher LCC due to initial cost - but designers should have flexibility to use drywall ceilings
- Prohibition of insulated T-bar based on comparison to insulated roof decks

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Proposed Standards Language

SECTION (118g or 125) - MANDATORY REQUIREMENTS FOR INSULATION

- ***Nonresidential and high rise residential roof/ceiling insulation placement:*** Insulation installed to limit heat loss and gain through the top of conditioned spaces shall be 1) in direct contact with the top side or underside of the roof deck or 2) in direct contact with a continuous ceiling that forms an air barrier. Insulation placed on top of movable ceiling tiles shall be deemed to have no effect on envelope heat loss.
- ***Exception:*** When the average height of the space between the ceiling and the roof is greater than 12 feet, insulation placed in direct contact with the ceilings having movable ceiling tiles shall be an acceptable method of reducing heat loss from a conditioned space and shall be accounted for in heat loss calculations.

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Changes to Section 143

- Prescriptive Requirements for Building Envelopes
- Alert readers to limitations on lay-in insulation

143 (a) Envelope Component Approach.

1. Exterior roofs and ceilings. Exterior roofs (and ceilings where allowed in Section 118(g)) shall have either an installed insulation R-value no less than, or an overall assembly U-factor no greater than, the applicable value in Table 1-H or 1-I.

Mandatory Requirements for Recessed Lighting in Continuous Ceilings

SECTION 133 - Recessed Luminaires in Insulated Ceilings

- Luminaires recessed into insulated exterior ceilings complying with section 118(g)2, shall be:
- approved for zero clearance insulation cover (IC) by Underwriters Laboratories or other testing/rating laboratories recognized by the International Conference of Building Officials,
- and shall include a label certifying air leakage less than 2.0 CFM at 75 Pascals (or 1.57 lbs/ft²) using ASTM E283 testing standards
- and shall be sealed with a gasket or caulk between the housing and ceiling.

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